APÉNDICE F

HOJA DE CUBIERTA

RE-EXAMINACIÓN DEL SINCRO DE TONEL PARA EL VG#1

Página 1 -	Carta de la Boeing, 22 de septiembre de 1994
Página 2 - 6	Informe del Análisis de la Calidad del Equipo, Giro Vertical número uno de COPA, Desensamblaje del Sincro de Tonel, discrepancias del fabricante, N°6663R
Página 7	Diagrama AA, mapa de daños
Páginas 8 - 25	Informe del Análisis de la Calidad del Equipo 6663R, fotografías de la A hasta la R.

Boeing Commercial Airplane Group
P.O. Box 3707
Seattle, WA 98124-2207

September 22, 1994
B-U01B-14921-ASI

Mr. G Phillips, AS-40
National Transportation Safety Board
490 L'Enfant Plaza East, SW
Washington, D.C. 20594

BOEING

Subject: Vertical Gyro Roll Synchro Lab Analysis, COPA 737-200, HP-1205CMP, Accident Near Tucuti, Panama, June 6, 1992

Reference: (a) Letter Phillips to Rodrigues dated May 31, 1994
(b) Equipment Quality Analysis Report No. 6663R, dated June 9, 1994

In your reference (a) letter, you requested that Boeing assist in the re-examination of the Roll Synchro from Vertical Gyro, P/N 2587335-12, S/N 8013167, installed on the subject airplane at the time of the accident.

Enclosed with this letter please find a copy of the reference (b) Equipment Quality Analysis (EQA) report detailing the findings of the laboratory analysis of the Roll Synchro. Copies of the report are also being provided to the other parties involved in the laboratory analysis.

If you have any questions, please feel free to contact me at any time.

Very truly yours,

FLIGHT TEST

[redacted]

for John W. Purvis
Director, Air Safety Investigation
Orgn. B-U01B, Mail Stop 14-HM
Telex 32-9430, STA DIR PURVIS
[redacted]
Datafax (206) 655-8533

Enclosure: As noted

cc: Mr. Luis Azcarraga, DAC
Mr. Don Lau, Honeywell
Mr. Anel Wong, COPA

EQUIPMENT QUALITY ANALYSIS REPORT

BOEING COMMERCIAL AIRPLANE GROUP
RENTON DIVISION

TO:	D. Rodrigues	14-HM	**NO:**	6663R
CC:	J. Balazic	2H-30	**DATE:**	September 22, 1994
	R. Christianson	2H-30		
	J. Purvis	14-HM	**CUSTOMER:**	COPA
			MODEL:	737-200
			REGISTRY:	HP-1205 CMP
			LINE NO.:	631

SUBJECT: *COPA, Number One Vertical Gyro, Roll Synchro Rotor Disassembly.*

IDENTIFICATION: Rotor, Roll Synchro
P/N: 2966049 (90012)
Removed from Vertical Gyro, Number One
Honeywell
P/N: 2587335-12
S/N: 8013167
VG #1 Modifications: A-Q,S,U,V,AA,AB,AC

BACKGROUND:

A roll syncro (servo) rotor, from the number one vertical gyro of a COPA 737-200, HP-1205-CMP, was submitted to the Equipment Quality Analysis (EQA) laboratory for evaluation. A request was made by the National Transportation Safety Board (NTSB) through Boeing Air Safety to inspect, disassemble, and evaluate the rotor windings, and document the same.

SUMMARY:

The NTSB team examined the subject rotor beginning on June 9,1994. Damage was observed on certain parts of the exterior windings of the rotor assembly. In addition to the physical damage, a manufacturing discrepancy was found. The manufacturing discrepancy consisted of a looped wire

intermittent short

from the roll synchro winding that was trapped or pinched against the iron core at pole number five. At the time of receipt into the EQA laboratory, this discrepancy was detected as a 9 to 10 ohms electrical shorting path from the yellow lead wire to the iron core. Later in the analysis, this shorting condition disappeared when the wire was freed from its entrapment, later in the EQA analysis. No other significant findings were observed during the disassembly of the windings.

RECEIVING INSPECTION RESULTS:

The NTSB investigation team convened at the EQA laboratory on June 9, 1994. In attendance at the laboratory sessions on June 9th and 10th, 1994, were representatives of the Panamanian DAC, COPA, Honeywell, the NTSB and Boeing.

As received, the rotor had already been removed from the vertical gyro as a result of previous testing performed at Honeywell. The rotor was received in a plastic bag which identified the contents as the roll servo rotor from the number one vertical gyro.

The rotor was submitted with the request to perform an electrical continuity check, take photos, perform a visual inspection, perform a microscopic inspection and document with photos, use a solvent if necessary to unbind the windings (saving samples of the solvent), perform a chemical analysis of the solvent samples if necessary, unwind the rotor windings and to document all of the findings.

The rotor was first visually inspected and photographed to catalog the physical damage observed and to document the as received condition. See photographs A to F.

TEST RESULTS:

After visual inspection (prior to disassembly, chemical soaking or detailed microscopic examination), an electrical continuity test was performed on the rotor. The two lead wires were insulated, one with green insulation and the other with yellow insulation. The following tests and results were observed.

1. The first electrical resistance test was conducted across the green and yellow leads. An open circuit was noted.

2. Continuity testing between the green lead and the iron core hub noted an open circuit.

3. Continuity testing between the yellow lead and the iron core assembly noted an electrical short, with resistance fluctuating between nine and ten ohms.

Electrical resistance testing was performed with a Fluke multimeter, model 8842A, sampling at a current of approximately one milliamp.

DETAILED INSPECTION RESULTS:

For indexing and documentation purposes, an arbitrary point on the hub or iron core assembly was chosen and identified as pole number one. From this point, the 18 poles of the rotor were

numbered consecutively, in a clockwise direction. The orientation of the rotor in the assembly was not known as the rotor was submitted by itself, for evaluation.

Prior to a detailed examination, it was agreed by the parties, that it was necessary to remove the wire ties to facilitate viewing. The wire ties could not be removed without removing some of the conformal coating. The entire rotor assembly was soaked in a dissolving solvent, Dynaloy, Uresolve Plus 500, for a period of approximately two hours. Subsequently, the wire ties were cut and removed.

Visual and microscopic examinations were performed on the rotor. Several areas of physical damage and one manufacturing discrepancy were in evidence. See the enclosed diagram AA. The following damage was noted:

1. The number one pole was slightly damaged. The ends of the iron core segments exhibited some corner wear and end damage. Eight windings were damaged between poles number one and two. Two of the windings were separated at this location. See photograph G.

2. The number two pole exhibited some pole segment end wear. This pole exhibited the most physical damage with one of the iron core laminates bent outward as if from impact damage. See photograph H.

3. The number three pole exhibited some end wear of the laminated iron core. One of the windings at this location was flattened; one wire was abraded; no breaks were evident. See photograph I.

NOTE

4. The number four pole was evidenced by end wear of the iron core laminates. A manufacturing discrepancy was observed between pole segments four and five. A winding wire was trapped between a nylon plug and pole number five. It appeared that the wire had become entrapped at the time that the nylon plug had been inserted as it was coated with a conformal coating. The wire was pinched between the nylon plug and the iron core. See photograph J. There were some indentation marks on some of the inner windings of the rotor adjacent to poles numbers four and five. There were no broken wires at this location. See photograph K.

5. A broken wire was noted between pole numbers six and seven. The most likely cause for this wire break is due to damage incurred during removal of one of the wire ties. Examination of the wire ends noted tapered ends indicative of tensile overload. In addition, abrasion marks on three wire strands located immediately below the broken wire seem to lend support to the idea that the broken wire was pulled across the other wires. No other damage was noted in the vicinity of the broken wire. See photograph L.

6. Adjacent to pole number eight, at least four wires show some impact damage. The damage was characterized by smearing and flattening. See photograph M.

7. Between poles ten and eleven, at least thirteen wires were damaged. The damage was characterized by flattening, smearing and abrasion. See photograph N.

8. One wire was flattened adjacent to pole number thirteen. The wire was not separated. See photograph O.

9. One wire was flattened adjacent to pole number fifteen. The wire was not separated. See photograph P.

10. Pole number seventeen exhibited end wear damage as well as significant damage to the wire windings between poles number seventeen and eighteen. At least twelve wire strands were damaged with at least two separated. See photograph Q.

11. Pole number eighteen was characterized by end wear and damage. The adjacent areas had suffered extensive damage. Between poles eighteen and one, there were at least fourteen damaged wires with at least six broken wire ends visible. See photograph R.

A review of the damaged areas notes that the primary area of significant impact damage to the wire windings occurred in-between and on the "back" side of poles seventeen, eighteen and one. The "front" side of poles number one, two, three and four exhibited the most significant pole damage. This evidence would tend to support the premise that impact and rebound were the primary cause for the physical damage observed in these areas.

EVALUATION and ANALYSIS:

The rotor windings could not be unwound without additional soaking. The rotor was submerged in the Uresolve overnight for approximately 12 hours. Some resistance was met when attempting to extract the nylon plugs, so an additional soaking in a second solution was initiated. The rotor was submerged in MS-114, Conformal Coating Stripper made by Miller-Stephenson, for a period of two hours.

After removal from the stripper, the nylon plugs were removed from the spaces between poles, numbers one, two, three, four and five. Three of the plugs were freed quite easily. The fourth plug (between poles four and five) could not be extracted at first. It appeared to be wedged by a combination of some conformal coating (underside of plug), the tension between the plug and the yellow wire insulation and by the entrapped copper wire. A dental probe was used to push the plug out.

Immediately after the plug was removed, the continuity tests were repeated. The discrepant condition of the short circuit between the yellow wire and the iron core had vanished. The testing confirmed an open circuit between the yellow lead wire and the iron core. An open circuit was measured between the green and yellow lead wires. The green wire was still open to the iron core. This condition supports the premise that the electrical short was caused by the pinched wire (between the nylon plug and pole number five). This section of previously entrapped wire was removed for further metallurgical evaluation. The results of the metallurgical evaluation are enclosed. See Analytical Engineering Report No.: 9-5576-WP-94-346.

The remaining wire was unwound from the iron core. The process of disassembly required two additional periods of soaking in Uresolve for a total of twenty two hours, before all of the wire could be removed from the core assembly. Nothing unusual was observed during removal of the remaining wire. All of the unwinding was performed under a microscope at magnifications between 10X to 63X.There were no breaks in the wire closer to the core. All of the observed damage was found towards the exterior of the windings and out on the periphery of the iron core assembly.

SUMMARY and DISCUSSION:

Except for physical damage to some of the exterior windings, the only significant observation of note was the wire found pinched between the nylon plug and iron core, pole segment number five. At the time of receipt, this discrepancy was detected as a nine to ten ohm short between the yellow wire and the iron core assembly. After removal of the nylon plug, freeing the trapped

intermittent short

(pinched) wire, the electrical short went away. No other electrical shorting paths were observed. The electrical opens were all traceable to separated wires which were damaged, presumably as a result of the impact or in the case of the broken wire between poles six and seven, to damage from removal of a wire tie.

The broken, flattened and cut wires on the outer windings were consistent with physical damage incurred as a result of impact. Optical comparator dimensions of the iron core assembly did not note any distortion of the iron core assembly from impact.

The preceding information is being submitted to the concerned personnel for action as necessary. No further action is being contemplated upon the subject rotor by the EQA group at this time and this EQAR is considered closed.

Prepared by [redacted]
James Murphy
M/S 96-03, 237-7400

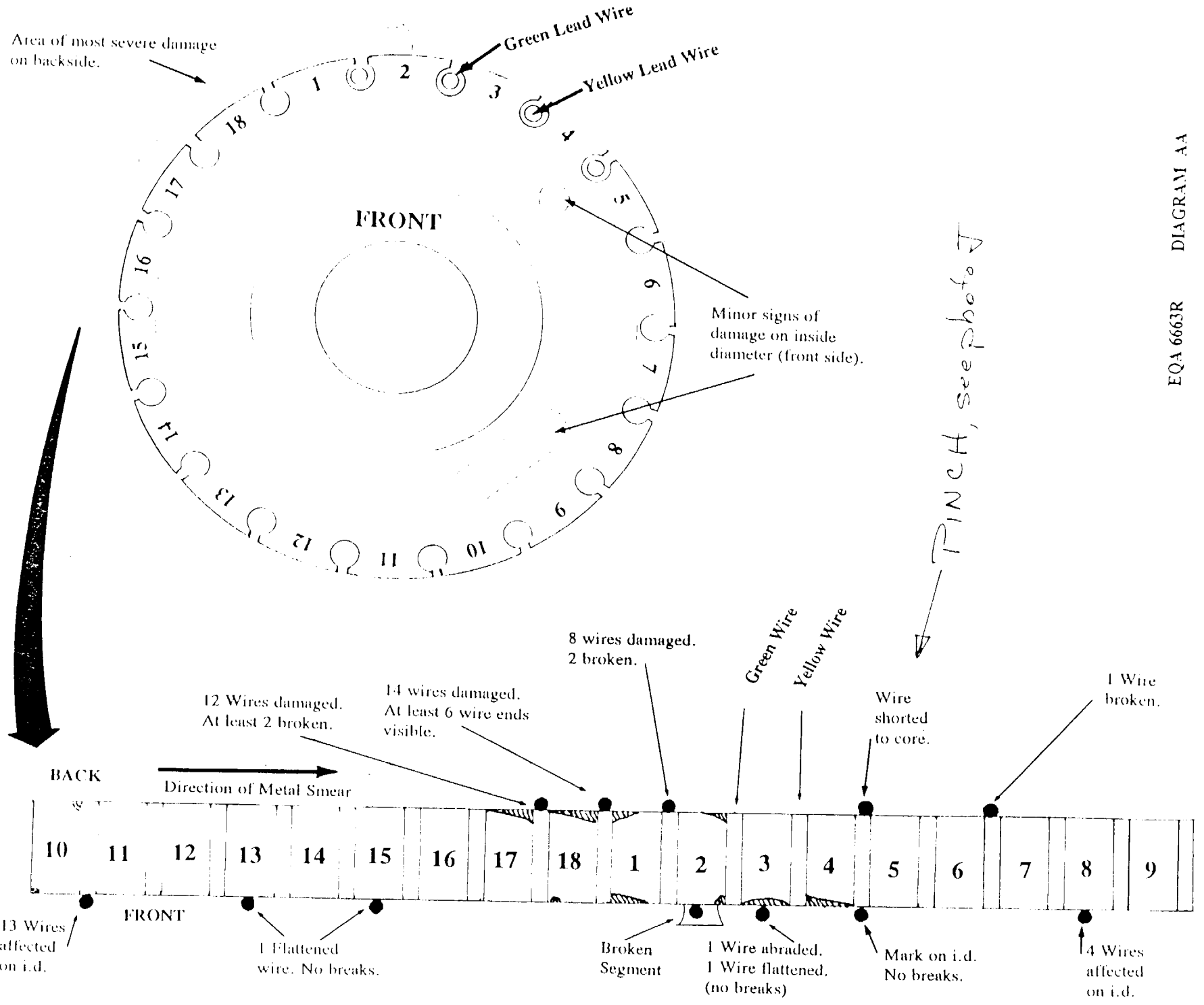
Approved by [redacted]
Gary Hines
M/S 96-03, 237-0086

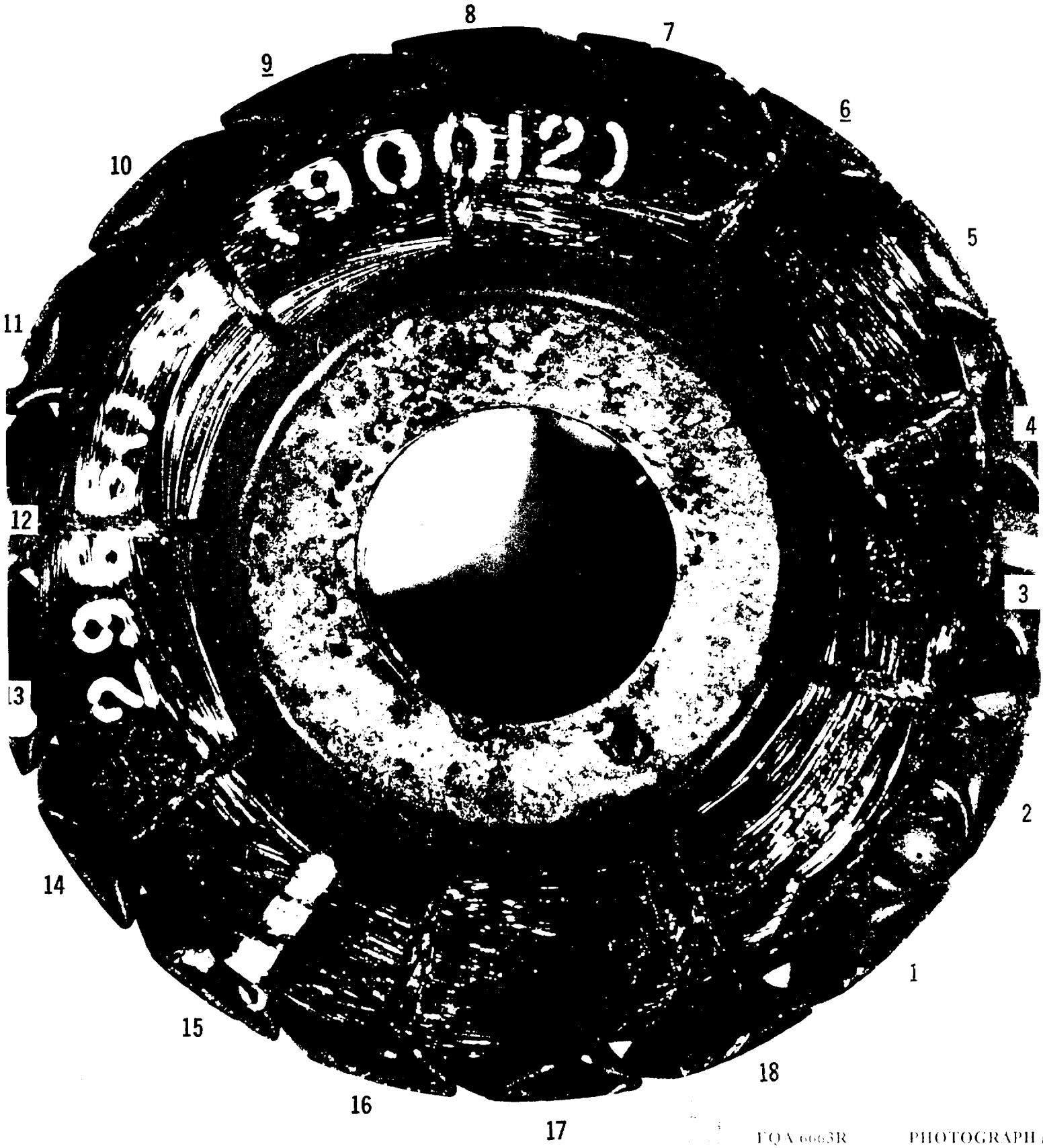
EQA 6663R PHOTOGRAPH A

Overview of the rotor in as received" condition. (Front view for analysis purposes)

EQA 6663R DIAGRAM AA

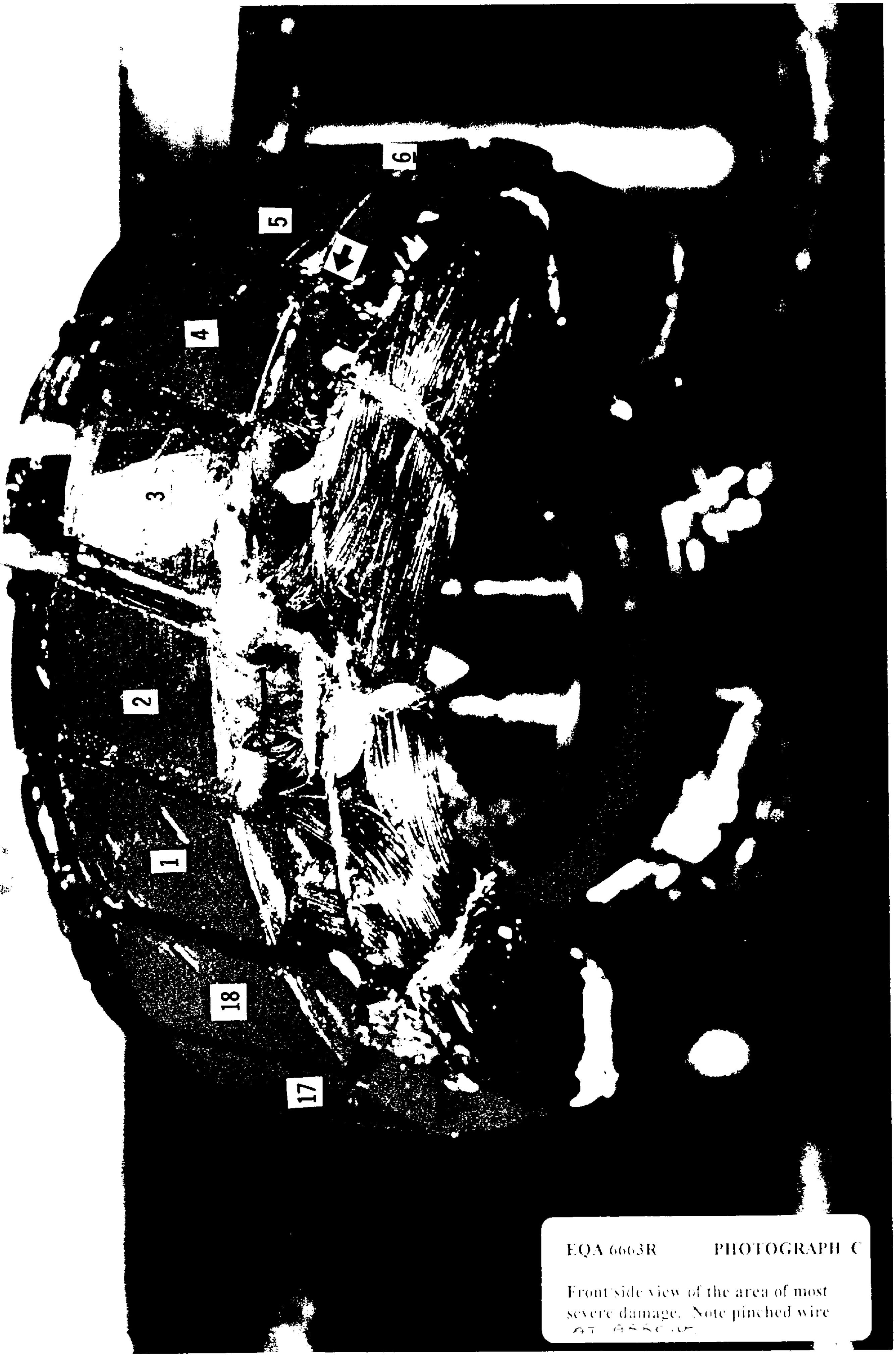
Map of damage seen on the rotor in the "as received" condition.





FQA 6663R PHOTOGRAPH 8

Overview of rotor in "as received" condition. "Back view"

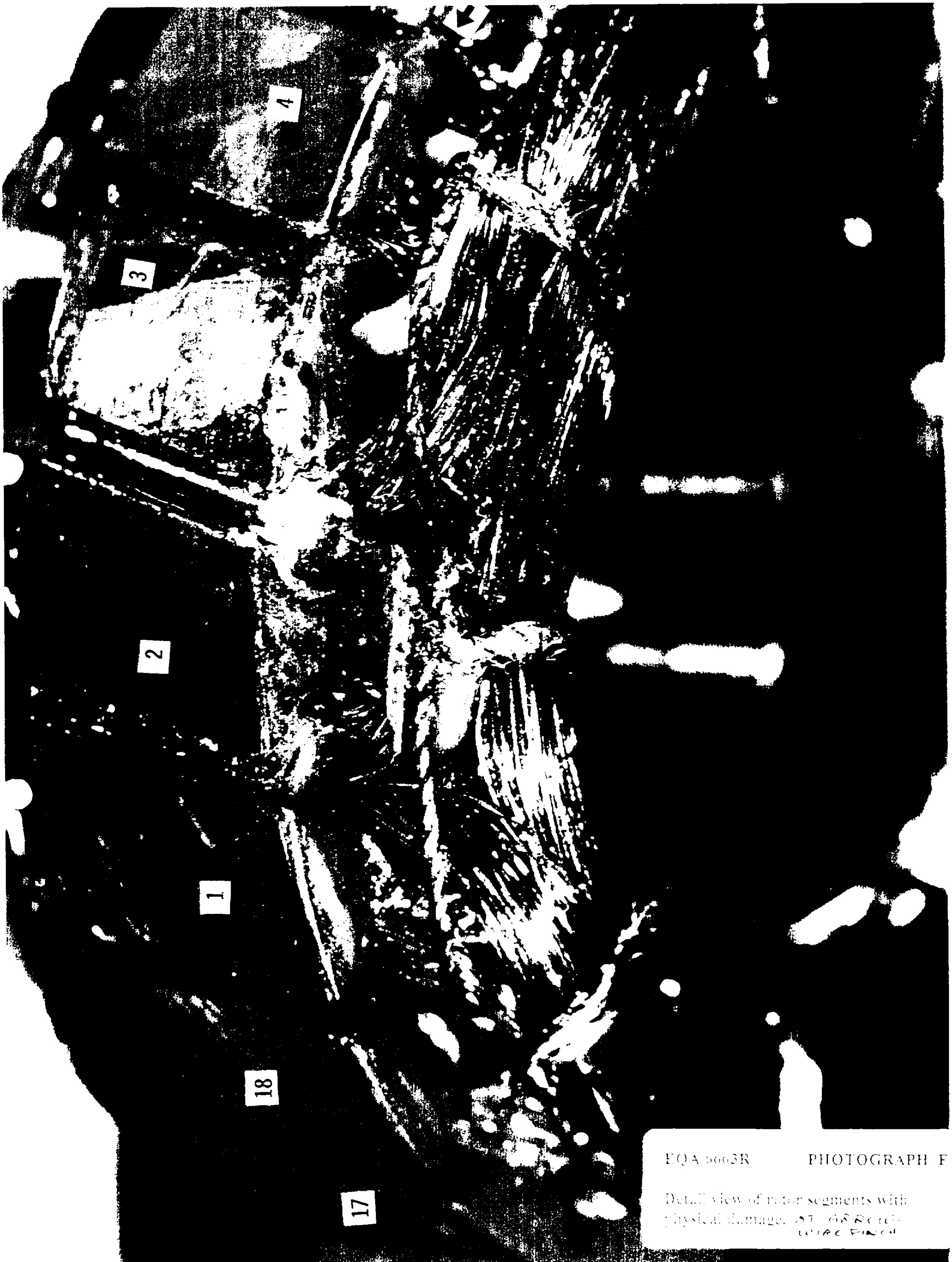


EQA 6663R PHOTOGRAPH C

Front/side view of the area of most severe damage. Note pinched wire [illegible]

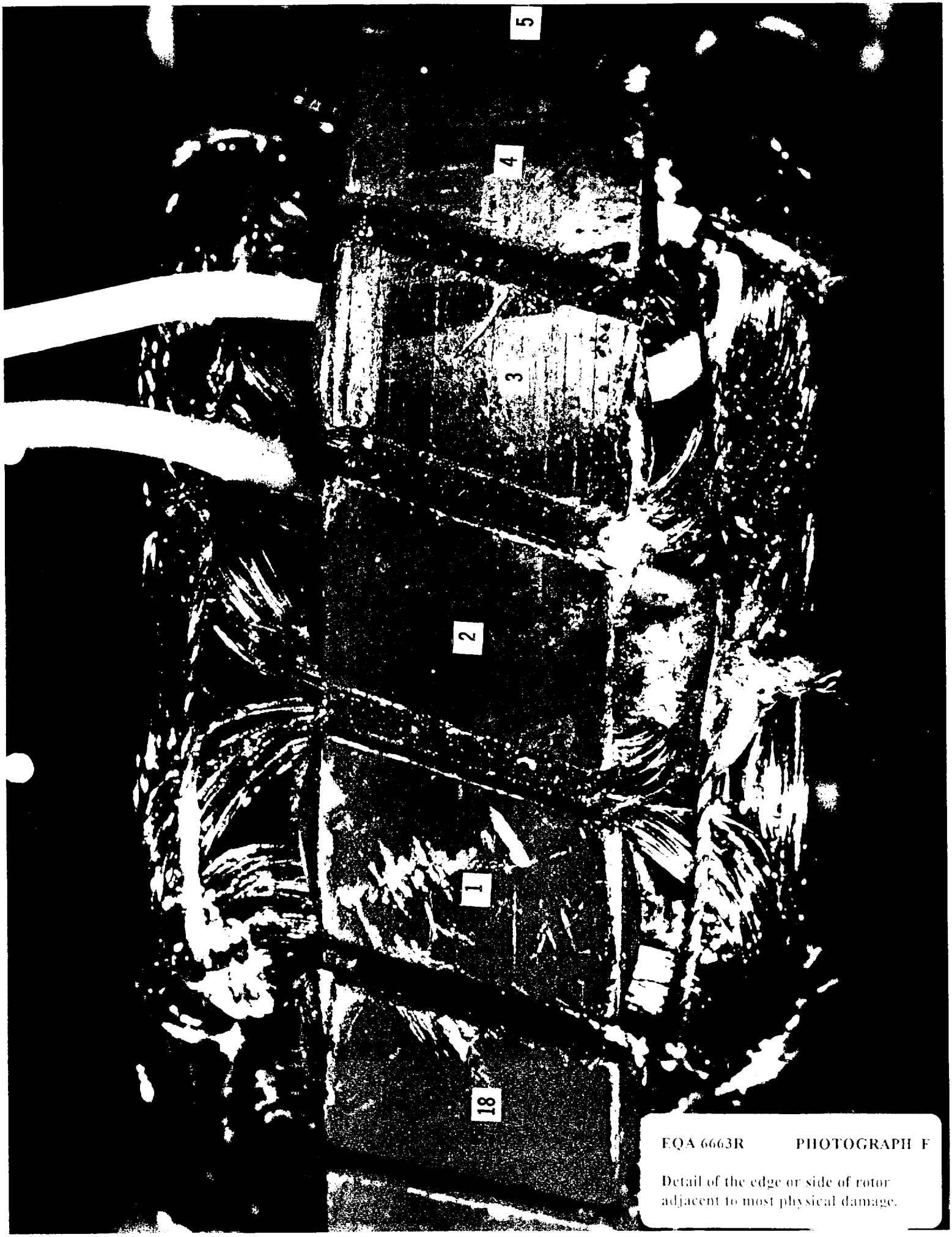
FQA 6663R PHOTOGRAPH D

Back/side view of area of most severe damage.



EQA 5003R PHOTOGRAPH F

Detail view of rotor segments with physical damage. AT ARROW- WIRE PINCH



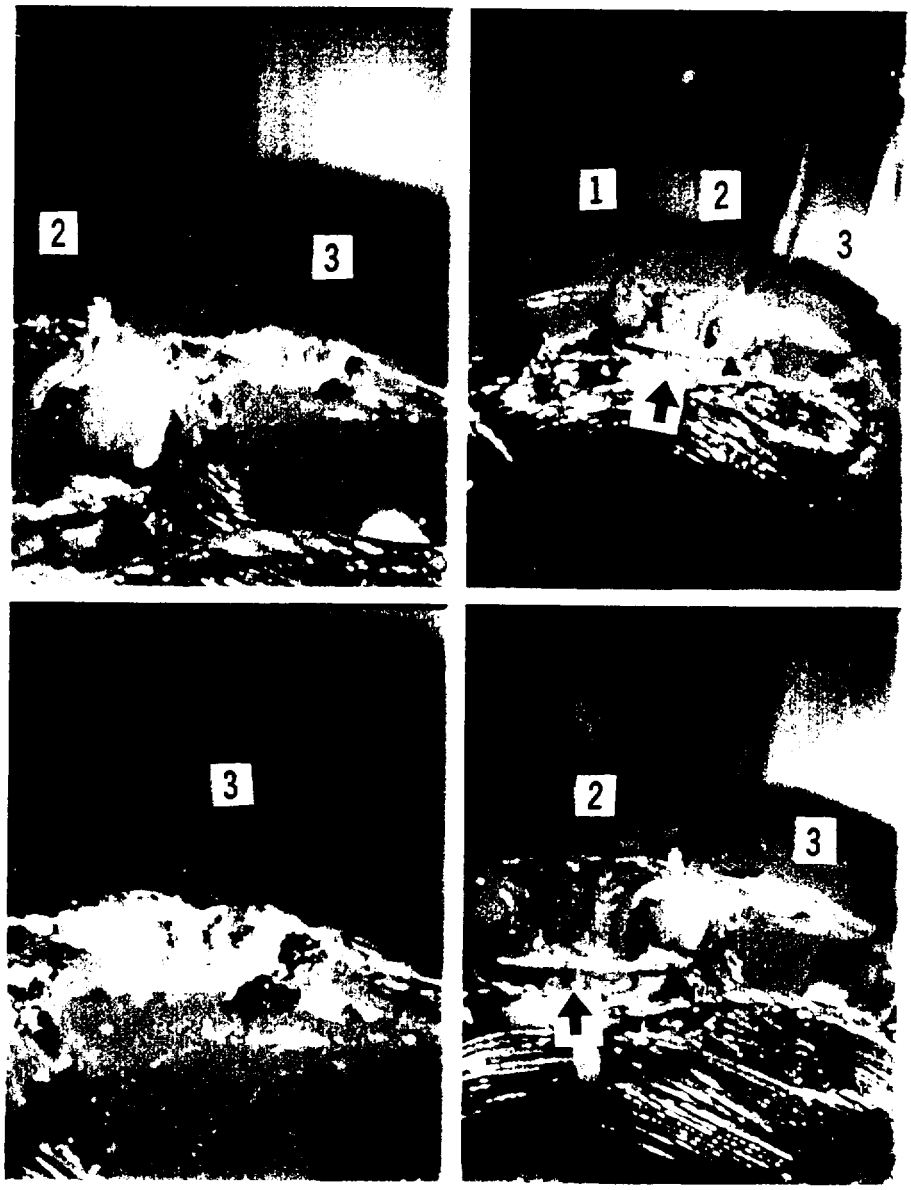
EQA 6663R PHOTOGRAPH F

Detail of the edge or side of rotor adjacent to most physical damage.

Damage between pole segments 1 & 2. Approximately 8 wires damaged, two are separated.

EQA 6663R PHOTOGRAPH G

Detail of area between pole segments 1 & 2.



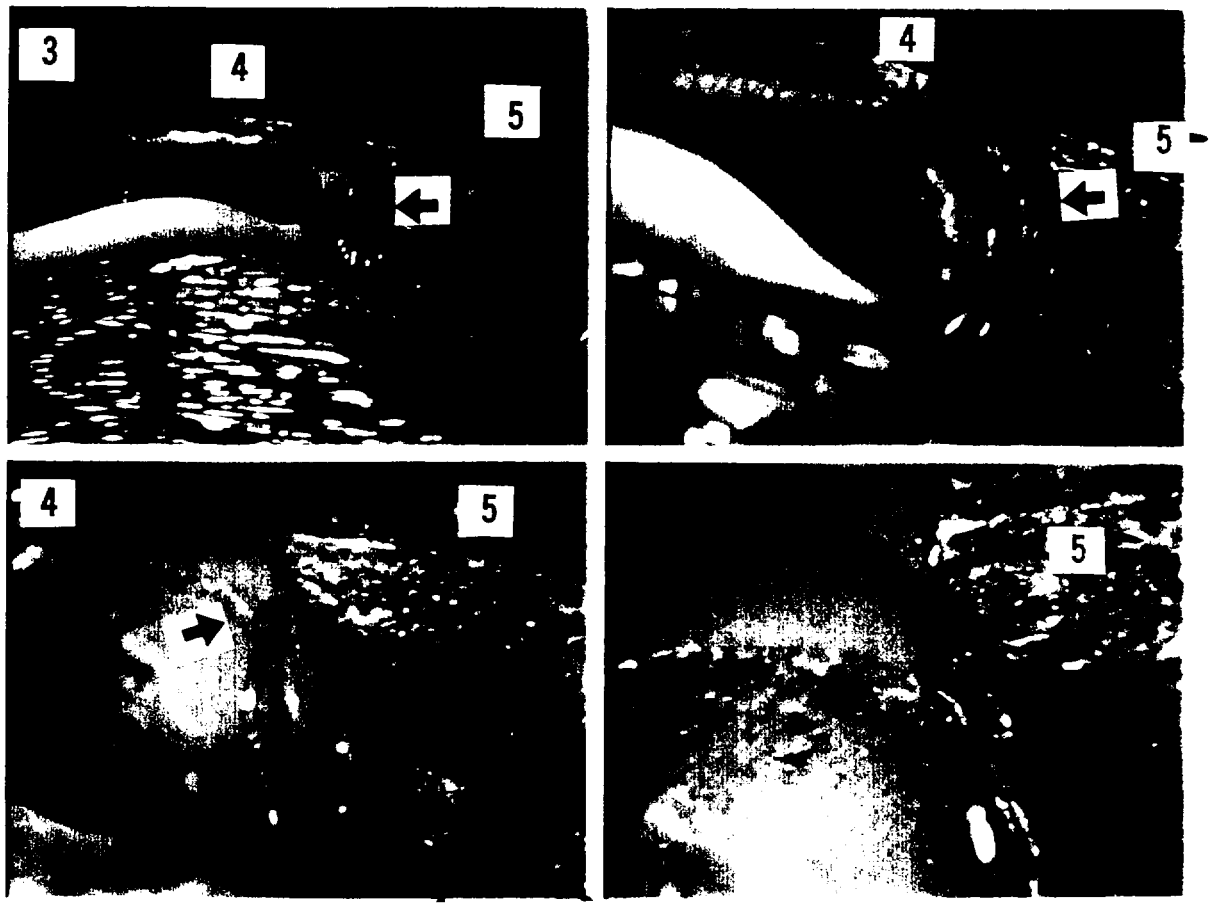
EQA 6003R PHOTOGRAPH H

Detail of damage at pole segment number 2. Note delamination of iron core.

Segment 3. Note detail of one abraded wire at lower left and one wire flattened and stretched at lower right.

EQA 6663R PHOTOGRAPH I

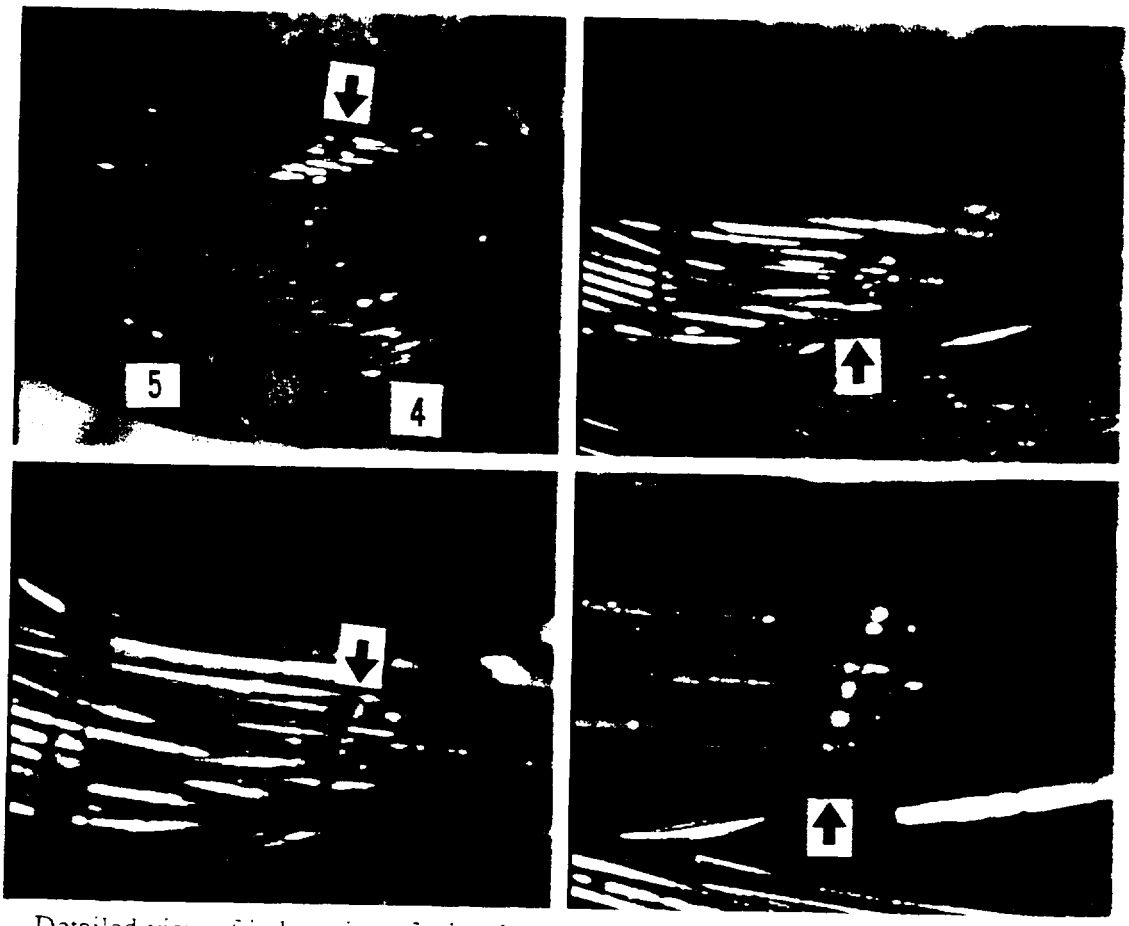
Detail of damage adjacent to pole segment 3.



Detail of the area between pole segments 4 & 5. Note the wire strand pinched between the nylon plug and segment 5.

EQA 6663R PHOTOGRAPH J

Detail of the area between pole segments 4 & 5. Note the wire strand pinched between the nylon plug and segment 5.



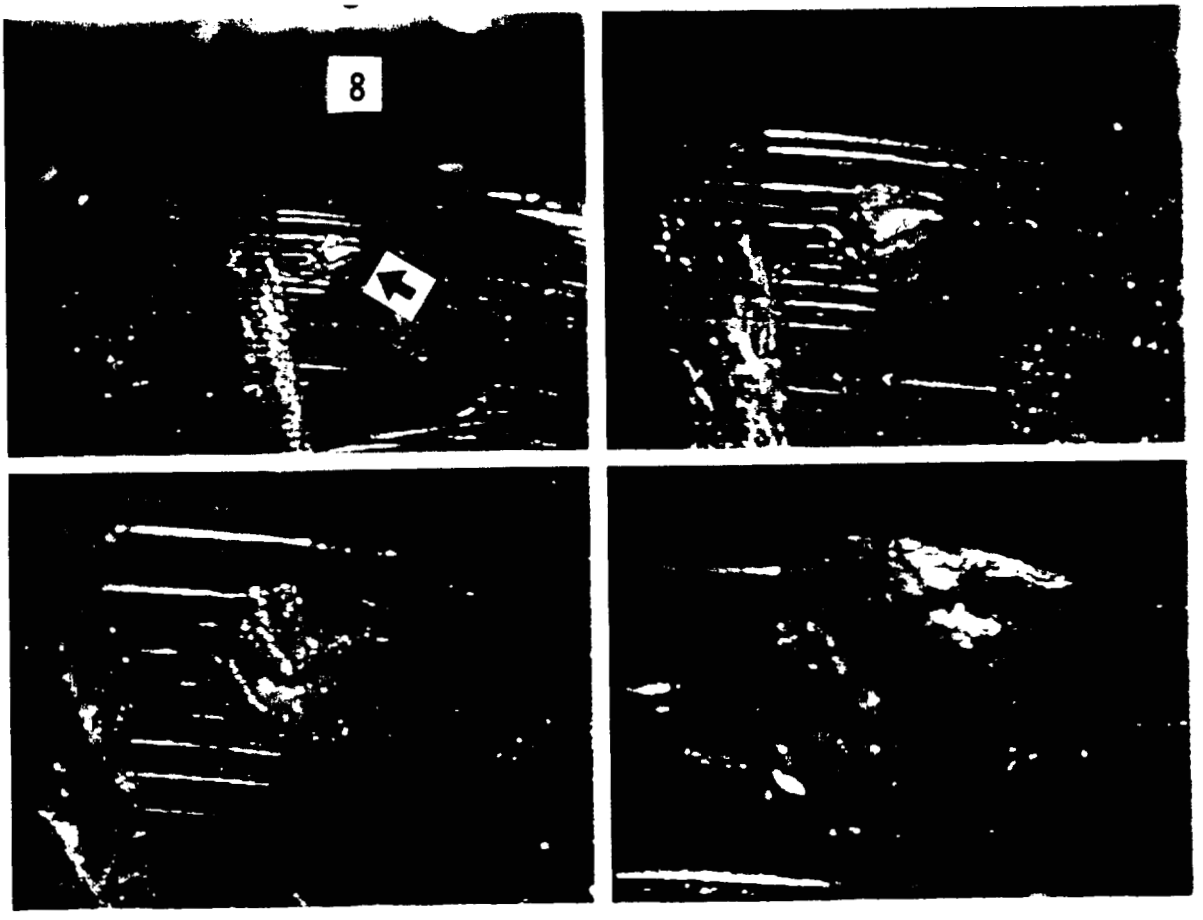
Detailed view of indentation of wires between pole segments numbers 4 & 5 adjacent to the center hub. None of the wires at the location appeared visually to be separated.

EXHIBIT PHOTOGRAPH K

[illegible]

EQA 6663R PHOTOGRAPH L

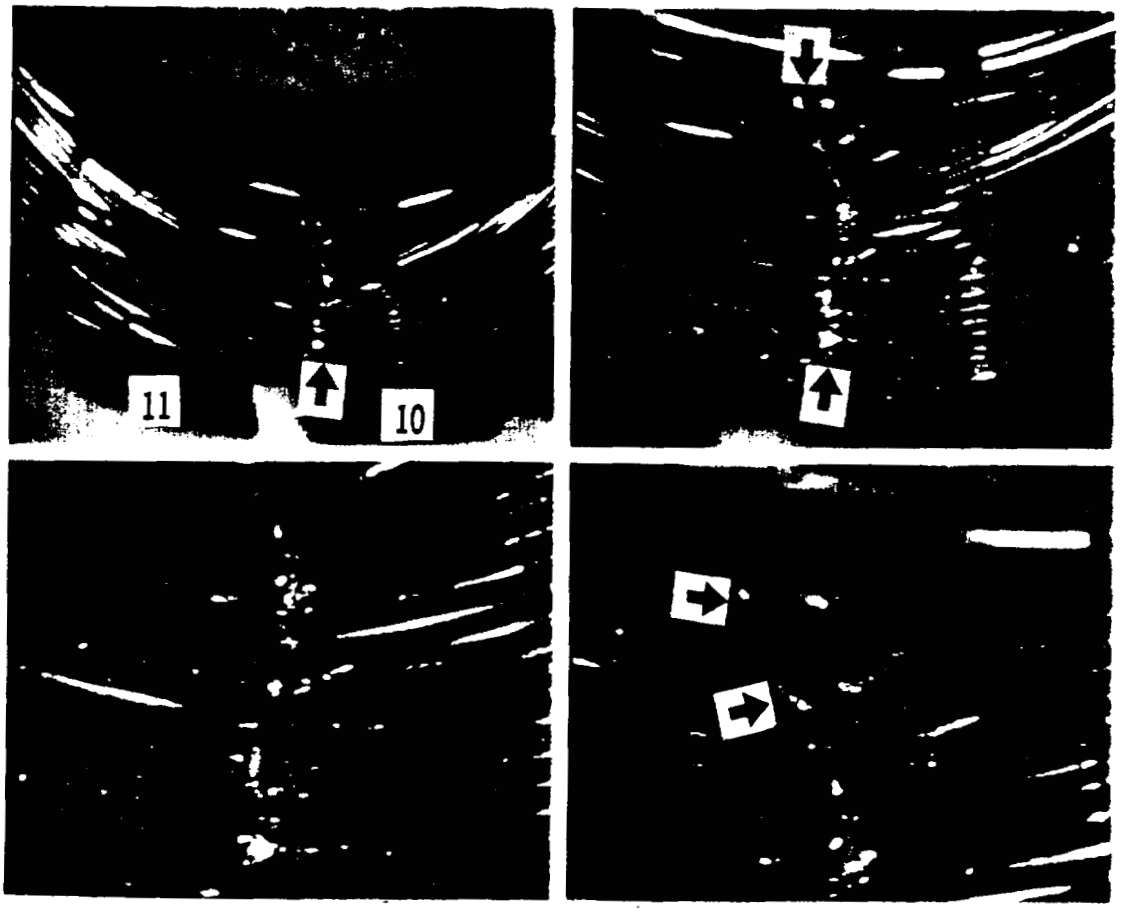
Detail of broken wire between pole segments 6 & 7.



Detailed view of at least four flattened wires adjacent to segment 8 (front side).

EQA 6663R PHOTOGRAPH M

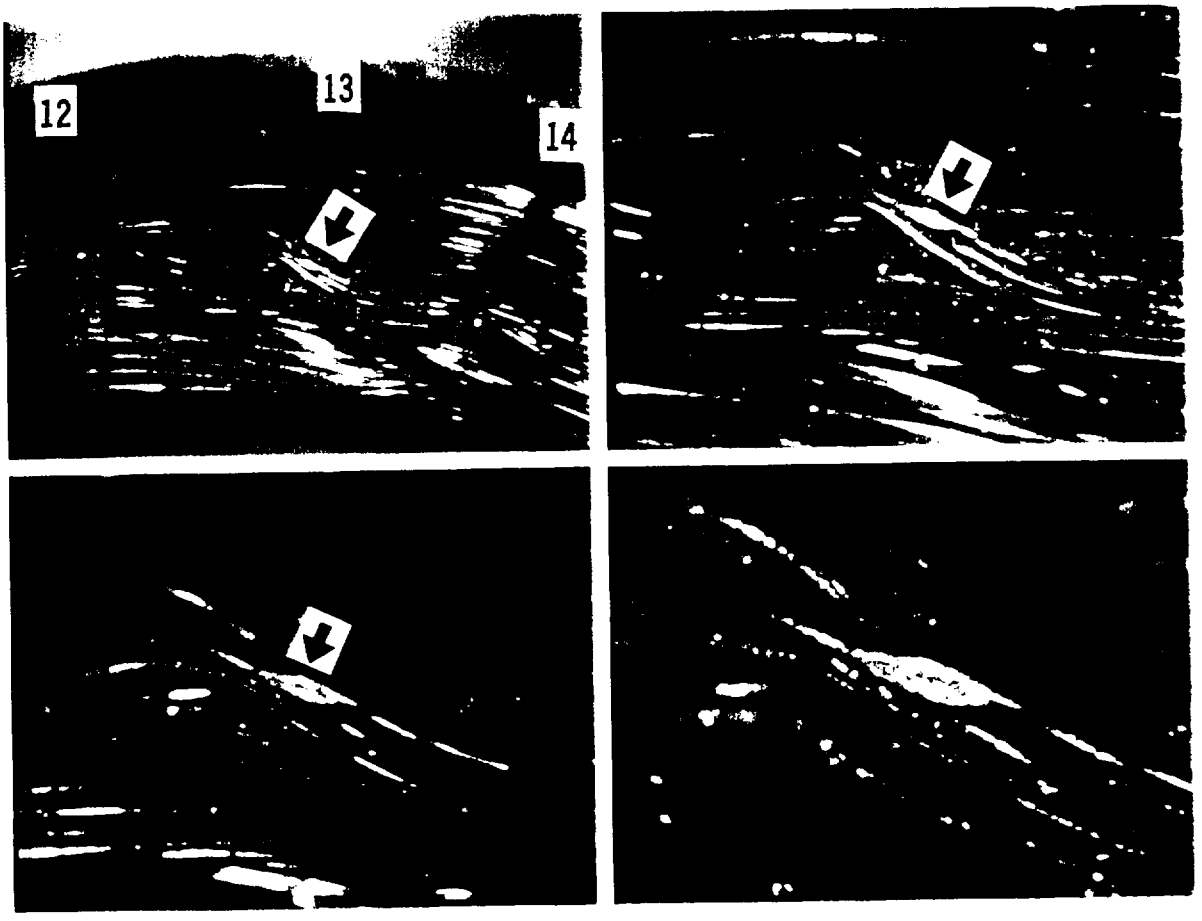
Detail of wires adjacent to pole segment number 8.



Detail view of at least thirteen damaged wires between segments 10 & 11 on front side
None of the wires appear visually to be separated.

EQA [illegible]3R PHOTOGRAPH N

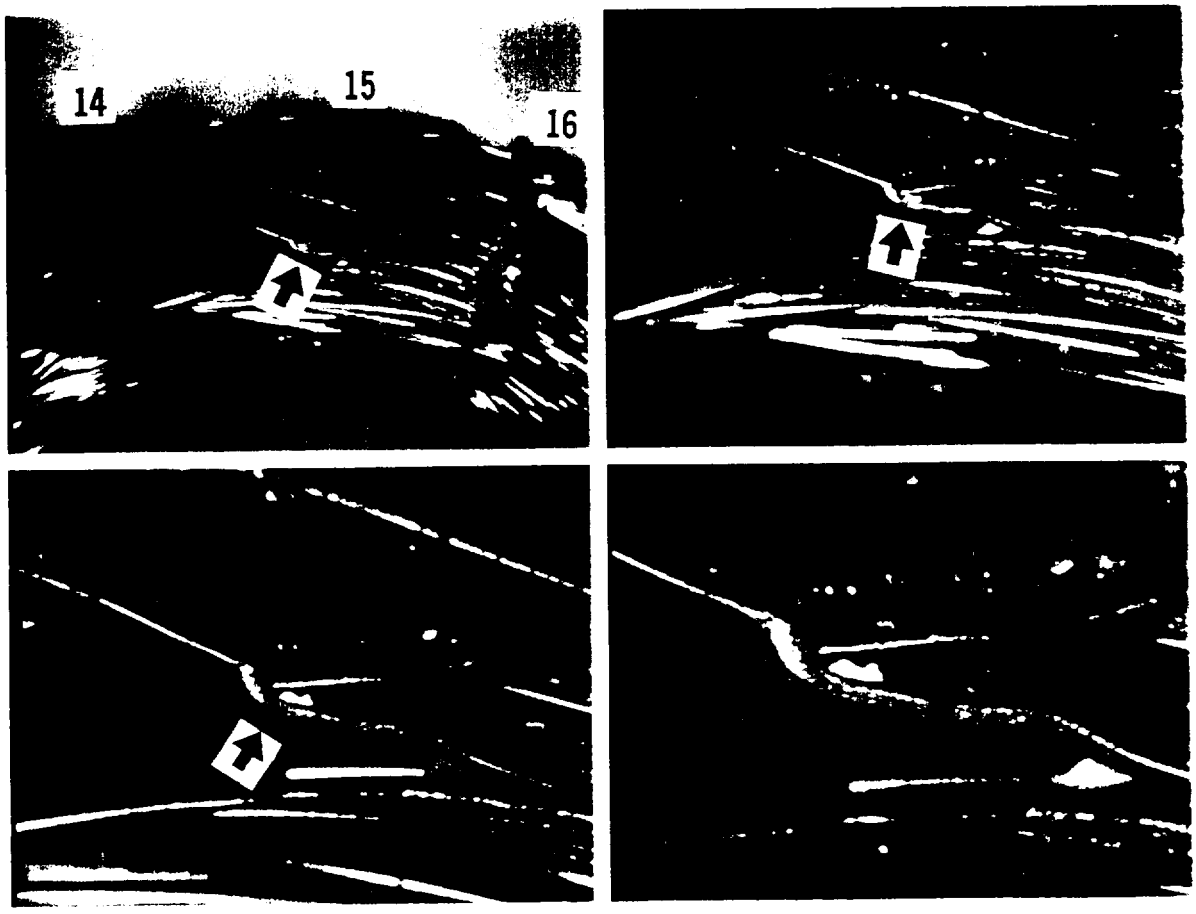
D[illegible] segments 1
& 11



Detail view of one flattened wire adjacent to segment 13.

EQA 6663R PHOTOGRAPH O

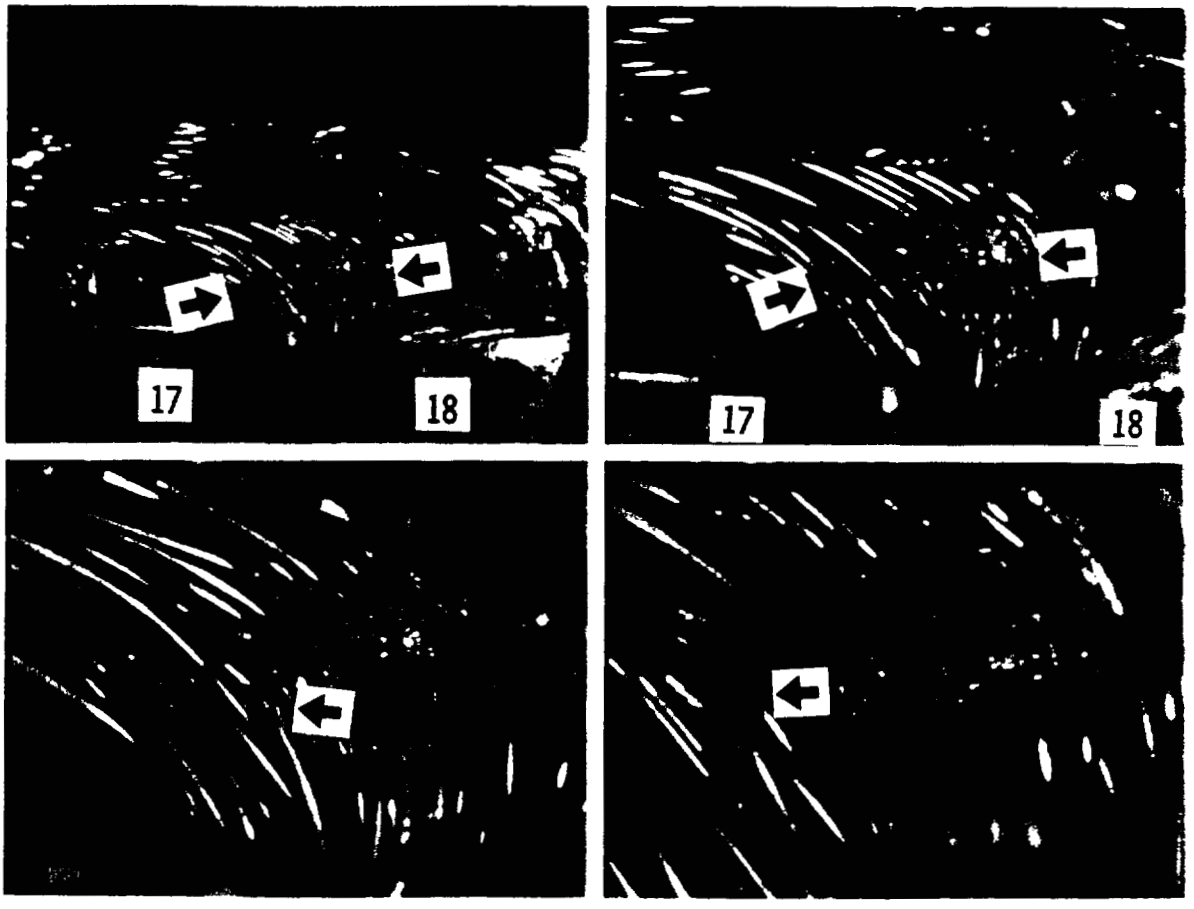
Detail of area adjacent to pole segment number 13.



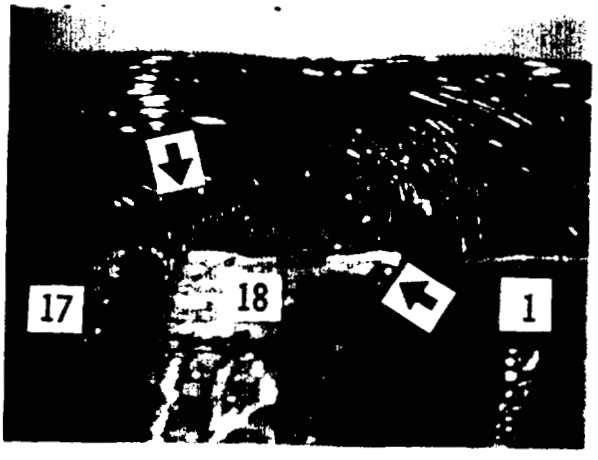
Detail view of one stretched, flattened wire adjacent to segment 15.

EQA 6663R PHOTOGRAPH P

Detail of area adjacent to pole segment number 15.

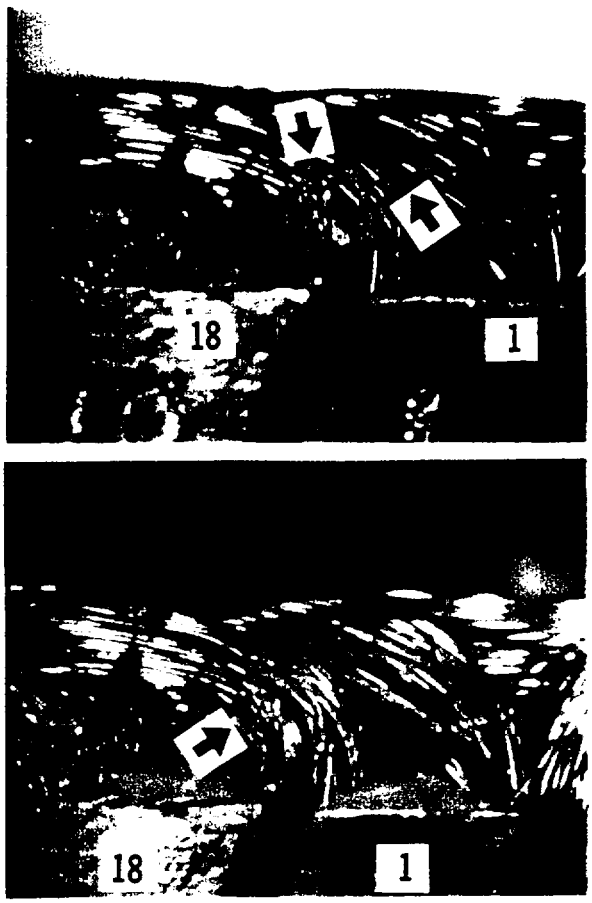


Detail of damaged wires between pole segments 17 & 18 (edge, backside).
Approximately 12 wires were affected with at least two separated.

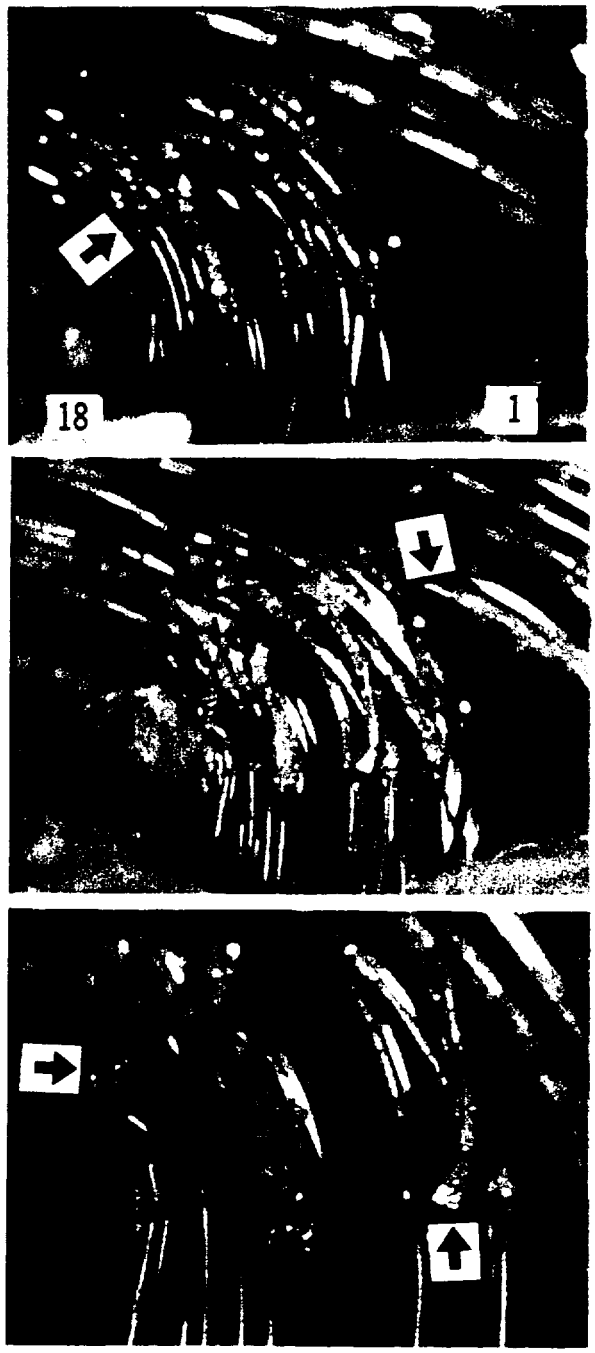


EQA 6663R PHOTOGRAPH Q

Detail of area between pole segments numbers 17 & 18.



Detail of damaged wires between pole segments 18 & 1 (edge, backside). Approximately 14 wire windings were affected with at least 6 wire ends visible.



EQA 6663R PHOTOGRAPH R

Detail of area between pole segments 18 & 1.